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THE CURRENTS OF THE PACIFIC OCEAN.

BY

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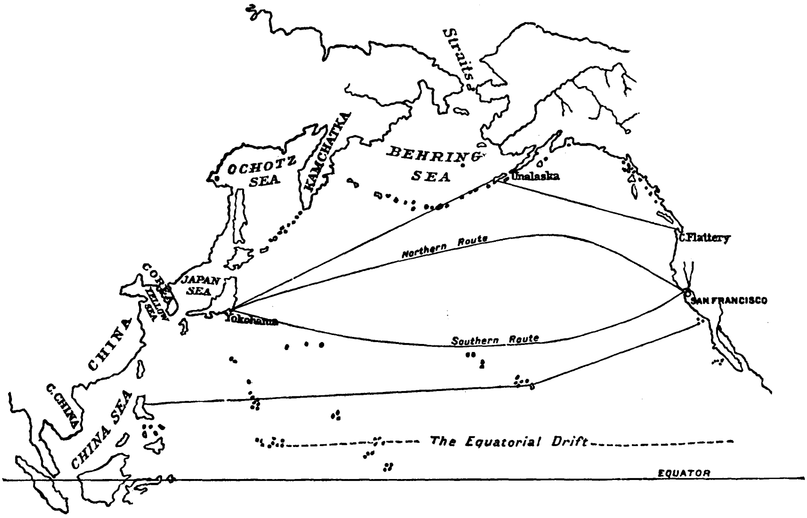
A complete consideration of the Pacific ocean would involve the study of very many other subjects than that which I bring before you to-night. Until very lately we have accustomed ourselves to look upon our globe in a narrow and restricted way, to take it apart, as it were, and examine it by piecemeal, by which method very partial knowledge and unconnected details could only be ascertained. Even as regards the more particular subject of this essay, I could say but little exact concerning the grandest current

MAP A.

GENERAL MAP OF THE PACIFIC OCEAN



of all, the great substratum of our aqueous element, the southern current, as it is termed, derived from the melting snows and ice of the South Pole, which, finding its way by its density, gradually sinks beneath the surface of the deep waters of the southern hemisphere and subsides into the troughs and submarine valleys, and moving in its ocean bed slowly even as far as the North Pole. A knowledge of this current has only of late years dawned upon us, and for a knowledge of which we are indebted to our explorers and navigators; a work in which almost every civilized nation has contributed its quota. I have limited myself this evening to some remarks on the currents of the Pacific ocean, in its northern portion, and eminently to its principal current, the Kurosiwo,* or the warm stream of Japan.

Fritsche, director of the Imperial Russian Observatory at Pekin, in his essay on the climate of Eastern Asia, writes: "The greatest of all the currents in the Pacific ocean is that called the equatorial stream, produced by the differences in temperature between the pole and the equator, and by the daily rotation of the earth around its axis from west to east. In the Pacific ocean, north of the equator, this current is included between the parallels of 20° and 10°; its depth is considerable. In the ocean it runs almost exactly from Central America in the east to west, as far as the southern end of Formosa and the northern portion of the Philippine islands. There, near the tropic of Cancer, partly in consequence of rebounding against these islands, partly because along the coast of China from north to south there runs a cold current, the equatorial stream changes its direction and one part turns to the north, and near the latitude of 30° becomes divided into several branches." * (See Map D, p. 122.)

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* This name is spelled indifferently as one or two words by the Japanese, but always pronounced in the dialect of Tokio as one word, with the accent on the *s*, as Kurȍskiwo.

The origin and source of movement of the Kurosiwo or great warm current of the North Pacific ocean lies in the China sea between north latitude 10°-20° and east longitude 120°-130°. At that point the equatorial drift current is arrested in its westward course by being brought up against the Philippine islands, a range of submarine mountains having a trend nearly due north and south for eight hundred miles, and thus the stream has the direction of its current changed into a northeasterly course; mingling with the waters of the Philippine seas and those of the China sea it acquires an enlarged volume and increased temperature, and under tidal influences and conditions becomes a new current which has received the name of Kurosiwo, or "Black Current or sewer," a name given to it alike by the Chinese and Japanese. The cradle of this warm current is the China sea, which is shallow as compared with the ocean depths east of the Philippines and therefore easily heated up by the intertropical solar rays, having a yearly mean temperature of 80° Fahr. Owing to the new forces brought to bear upon it, it assumes a new direction which, according to the law of composition of forces, is to the north and east, and it is now, thereby, made subject to a new impelling force—the monsoons or the season winds of Eastern Asia.

In the pages of the "Chinese Commercial Guide," published at Hong Kong by S. Wells Williams, much information is given of the movement and navigation of the Chinese waters. From it is learned that the currents of the

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* "Climate of Eastern Asia," by Dr. H. Fritsche, published by the North China branch of the Royal Asiatic Society.

southern coast of China are largely produced and influenced by the same atmospheric conditions as those which govern the Asiatic coast north of the tropic of Cancer, and of these the chief and most powerful are, as stated, the monsoons or trade winds, which blow with periodicity and force and tolerable regularity. Along these shores and stretches of the ocean where they blow unrestrained, their influence over the sea is uncontrolled, and after a few days, or sometimes even twenty-four hours, a well-established current appears and continues so long as the force of the wind predominates. When from any cause that force is lessened, the current of water loses its velocity and even ceases to move for a while; or from winds from either side rushing in, the current appears moving in a retrograde direction. These variable conditions of current are seen everywhere over this wide ocean, so that occasionally one doubts the existence of a current at any fixed point where it had been frequently met with, but all doubts vanish at another visit to the same place when it will be found re-established in its old direction. This observation will sufficiently explain the conflicting accounts given by mariners as to the existence or non-existence of a current at any special point, and we proceed to the further consideration of the influence of the monsoons.

These season winds blow with great force and regularity; the winter or northeast monsoon from 10th September to about 1st April, and the summer monsoon from mid-April to November. The influence of these two monsoons is very different upon the surface of the North Pacific. The southwest wind is the motor of the currents of the sea developing them and producing the circulation of its waters—it alone is usually termed *the monsoon.*

Wells describes this southwest current as flowing south of the point here described along the coast of Cochin China, from Pulo Obi to C. Padaran, and setting mostly to the east-northeast from April to the middle of October, and during the same period its direction is generally northward along the eastern coast of the Malay peninsula from Singapore strait to the gulf of Siam.*

Following up the south coasts of China sea these united currents run eastward and increase with the freshness and duration of the monsoon, varying from one to three and four knots per hour, from north latitude 10° to 14°, increasing in volume and strength and running from forty to sixty miles in twenty-four hours. When this current in spring, in passing along the Philippines meets with the equatorial drift, it mingles with it, carries a portion of the drift northward, and receives by it increased volume and warmth. Off Palawan and Luzon the current passes north in May, warm and running fifty miles per day, and accompanied by furious gusts and typhoons, produced by the warm sun of the China sea; it soon reaches the Bashi islands, in latitude 20°, and the south point of Formosa, which it rounds and travels up the east coast of that island, much of its current running between it and the Meiaco-Sima isles where the current in August is thirty to forty miles per day, without strong monsoons.

In May and June a broad warm current is found flowing around the shores of the Liu-Kiu islands and the Bonin islands, which it has already reached in April, producing variable winds before the monsoon was established in full influence. This current is felt off the shores of Japan, and has already received its Japanese title—the Black sea or current (Kurosiwo)—from the remarkable dark color which its waters exhibit when looking over the ship's side—it is a deep blue-black and it can be thus recognized with ease as soon as it is attempted to be crossed. The origin of this Kurosiwo, the great warm current of the Pacific, has been thus traced—cradled in the China sea, the offspring of the equatorial drift and its warm currents among the Philippine islands. When it passes Formosa in early summer, it is already a powerful current and begins to send off lesser currents while proceeding on its northern route.

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* "Chinese Commercial Guide." By S. W. Williams. 5th edition, p. 208.

Immediately north of Formosa, and between it and the Bashi islands, the first branch of the current emerges from its western side about the latitude of 30°, flows north by east, enters the eastern and Yellow seas, warming the western shore of Corea, and, losing its high temperature in the gulf of Petcheli, returns to the south along the coast of China as a cold current.

Another branch, a narrow one, is given off as the current reaches the southern shores of the Japanese islands, passes up through the Straits of Corea, warming the Sea of Japan both on the eastern side of the Corean peninsula and the western coast of the large island of Japan; passing farther north this current mingles with the waters of the Sea of Tartary and sends lateral currents eastward through the Straits of Tsugaru and of Lapeyrouse to intermix with the cold waters off the shores of the Kurile islands and of Kamchatka. On account of the frequent northwest wind blowing off the Manchurian shores this current is driven with violence through the channels between the Kuriles, and appears a greater body of water than it really is.

But the great body of the Kurosiwo keeps on the eastern side of Japan, reaching the islands of Kiu-Siu and Shikoku in the south of that kingdom about the latter end of March or beginning of April, and soon after enveloping the Japanese islands completely on both sides in its warm waters, and pressing closer to the shores bestows its double Summer-rains and its consequent fertility from an atmosphere overloaded with moisture.

In early spring when the Kurosiwo arrives at parallel 30° north, it is but a narrow stream, being scarcely more than 100 miles wide at the Bonin isles, but rapidly as summer approaches the volume of water increases and the stream widens, until in July and August, and part of September, the influence of the Kurosiwo cannot be much less than 48 degrees wide, reaching as far eastward as 170° west longitude from Greenwich, or one-half the distance across the Pacific.*

The rate of motion of the Japanese current varies as the latter is near to land or farther out; in the open ocean, taken on the average, the current velocity is from 67 to 70 miles per day, rarely ever exceeding the latter amount. Among the Bonin isles, it is about 65 miles; opposite Kiu-Siu, Japan, 50–60 miles; off Cape King (main island), 70 miles; in the Corean straits and sea, 2–3 miles per hour.

Among the Bashi, Liu-Kiu and Bonin islands, even this moderate velocity meeting with obstructing winds and tides creates stormy waters, bad for navigation of small craft, and causes diminished velocity of current; and in Satsuma the violent forcing of the stream through the channels between Kiu-Siu and Shikoku during later spring is the terror of Japanese sailors.

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* See voyages 12 and 14 on Table of Temperatures, p. 126.

The Kurosiwo clings to the Japanese coast no further north than Cape Inaboye on the east side, where in latitude 38° it leaves the shore and takes a more distinctly eastern direction, apparently pushed out of position by the body of cold water coming from the sea of Ochotz and the western shores of Kamchatka. This latter current, known to the Japanese by the name of *Oya Siwo*, arises from the melting of the cold winter ice of the sea of Ochotz and around the island of Karafto; it flows southward to the Kuriles, and is forced by the cold northwest winds along the shores of Kamchatka and between the isles to the coasts of Hokaido and larger island of Japan. In extreme cold this region is frozen into an undistinguishable mass of compact ice frequently for twenty-one miles off the land. In this vicinity, in spring, from the west the Amour river pours large amounts of comparative warmish water into this unusually cold basin, which combined meeting with the freshly-arrived Kurosiwo, produces banks of fogs and rain, resembling the coast of Labrador and Newfoundland from similar causes. The Oya Siwo pursues its course south, along the Coast of Nambu, pushing, as already stated, the Kurosiwo eastward off land, and making coast navigation dangerous. From the middle of November to the vernal equinox the northwest wind blows off the Manchu coast with steady force, increased in the morning, lighter in the afternoon, frequently obscuring all traces of a current by reason of the cold sheet of water blown from Ochotz sea along the shores of Japan south as far as Tokio. Captain A. R. Brown, of the *Thabor* Japanese steamship, gives a striking illustration of the effect of the warm stream (Kurosiwo) and of the Oya Siwo cold stream, off the same coast of Japan, thus: "In April, 1873, sailing off Cape Inaboye, he found the sea temperature 62° Fahr.; in mid May following he fell in with the Oya Siwo and found the shore sea temperature had fallen to 42°." *

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* Transactions of Asiatic Society of Japan, 1874, Yokohama.

When leaving the shores of the larger island in latitude 38° the Kurosiwo washes the southeastern shores of Hokaido until it reaches cape Nimurro, the eastern extremity of that island, when it is deflected toward the southeast by the Kuriles, which blocks its further course northward and compels it to pass in parallels 45°–50° south of the point of Kamchatka to the Aleutian isles, where it bends to the southeast, sends some branches between the narrow pass of these islands into Behring sea, and in making its great curve to the southeast loses its distinctive character as a warm current and becomes the cool stream of the Pacific shores, as may be seen by examining the "Table of Temperatures" in the last five columns adjoining the San Francisco side.

No warm current flows north of the Kurile Islands along the Kamchatka shore.

Capt. A. R. Brown, of the Japanese Government Light House Service, in an interesting essay,* writes of it as a current of varying dimensions, its volume and breadth depending mainly on the winds of the China sea, being increased during southwest winds and lessened by northeast winds. The velocity of the current also is irregular and uncertain, varying from forty to seventy-six miles in twenty-four hours. He gives the following temperatures of the current around the Islands of Japan, as taken on the Japanese ship *Thabor*:

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*Winds and currents of the Japan Islands in Transactions of Asiatic Society of Japan. Yokohama, 1874.

TABLE OF TEMPERATURES ON THE "THABOR."

MONTHS.	Between Satano Misaki and Oshima.	Between Oshima and Miko Moto.
January	65 F.	69 F.
February	62	61
March	68	64
April	70	67
May	74	70–76
June	78	76
July	82	76–78
August	80	82–84
September	....	.....
October	80–85	76–79
November	.....	.....
December	64–72	71

Tsugaru straits (between Hokaido and large island):—

April	42
June	56

Capt. Brown states that the branch passing through the Corean straits does not flow in winter, owing partly to the opposing influence of the northeast monsoon, and partly to the northwest wind blowing off the Manchuria coast and producing currents rushing through Tsugaru and Lapeyrouse straits.

The following Table of Temperatures of the Kurosiwo is made up from the maps appended to Dr. Fritche's essay, from which I have already drawn for other information:

LOOALE OF STREAM. (Latitude N. and Longitude East Gr.)	MONTH.	TEMP., FAHR.
1. Off Keeling—(Formosa)	February	69.8
2. Longitude 140°—Latitude 33°	February	66.2
3. Longitude 142°—Latitude 35°	February	62.6
4. Tsugaru straits	February	50.
5. Northeast of Formosa, Longitude 126°.	February	69.8
6. Longitude 140°—Latitude 33°	June	77.
7. Longitude 137°—Latitude 36°	July	86.
8. Liu-Kiu	July	87.8
9. Longitude 156°—Latitude 44°	August	59.
10. Lapeyrouse strait	August	62.6
11. Corea straits	August	82.4
12. Tsugaru straits	August	75.2

Dr. Fritsche does not name the authorities on which these figures are given. The date of observation and locale of the current fixes the relative warmth of the current.

In crossing the Kurosiwo in summer, as in routes of the China Mail Steamship Company voyages, between San Francisco and Yokohama, when within 500 or 600 miles of the Japanese coast it is easy to recognize the Kurosiwo by its color and the floating drift matter; but it is not always easy at different times to recognize the width of this stream in the various months of summer, or where the borders of a stream, which is very liable to quick and great expansion under high temperatures and strong winds, are placed. By examination of the table of ocean temperatures a rough guess may be hazarded, but to determine the lateral limits of a warm river flowing through a cooler ocean is a problem which will require frequent and patient observation before it can be correctly solved. This table, and the profiles submitted, are but the commencement of this work.

TEMPERATURES OF THE PACIFIC OCEAN.

The Pacific ocean is bluntly closed at the north by the approach of the Asiatic and American continents, which is almost complete at Behring strait. Telluric disturbances with its geological results, the upheaval of submarine mountain chains have aided in effecting this change of the earth's surface more than other causes. The disturbances which in America led to the formation of the Rocky mountains along the Mackenzie and Upper Yukon rivers, appear not to have extended west of latitude 157° (Greenwich), but to have been transferred to the northeastern portion of the Asiatic continent, where volcanic activity was greatly exerted and is still evident in the existing fire-islands among the Aleutians and Kuriles, and along the whole peninsula of Kamchatka, marking the course of its power and extent by the shore lines of its seas, and by the trend of its mountain chains, promontories and islands. An unbroken volcanic subterranean force may be traced in a direction northeast and southwest from the Upper Yukon on the Arctic circle to the extreme Aleutian isles. Another line or wave of force nearly parallel extends from the head of the Anadyr river in Eastern Siberia through Kamchatka to Cape Lopatka, passing into the Kurile islands, which it has gradually elevated, then entering Japanese territory on its northern island (Hokaido), and passing to the extreme west of same, terminating on the Japan sea, where it meets another line of volcanic force of more ancient date and of more strictly northern direction which traverses the whole of Karafto, passing south through the west of Hokaido and under the large island of Japan, through Kiu-Siu and Shikok, where it is lost, perhaps to reappear in the Liu-Kiu islands. The mingling together of existing and extinct volcanoes, in the districts alluded to, point to the great extent of connected subterranean disturbance, embracing a line drawn from the Aleutian archipelago to the point of Kamchatka, and from that point by another line to Cape Nimurro, the eastern point of Hokaido; all these telluric upheavals give to the coasts approaching Behring strait, its broken continuity, and to the waters north of latitude 50°, an archipelagic condition.

Such great geological changes which this part of the earth has undergone has not been confined to the land only, but has extended along the ocean bottom, lifting it in places into high ridges or submarine mountains with corresponding deep valleys or troughs whose existence in the north Pacific has been clearly brought to light by the report of the soundings in this ocean, made by Captain Belknap in U. S. Steamship *Tuscarora*, both off the coast from San Francisco to San Diego and to Hawaii islands, as well as to the line of soundings taken by him from the Bay of Sindai, Japan, to the Kuriles, the Aleutians, and terminating at Cape Flattery, on the Oregon coast.* The deep longitudinal troughs in the ocean bottom, brought to light by the work on the *Tuscarora*, must exert great influence on the underflow of the great cold current already alluded to as flowing north from the South Pole, in turning it aside from passing into the Arctic ocean through the Straits, were it possible to do so (which it is not, owing to its present great shallowness), and forcing it to rise to the surface and form a portion of the great cool current flowing south on the American side of the Pacific, to finally mix with the equatorial drift at the tropic of Cancer, on the American side of the ocean.

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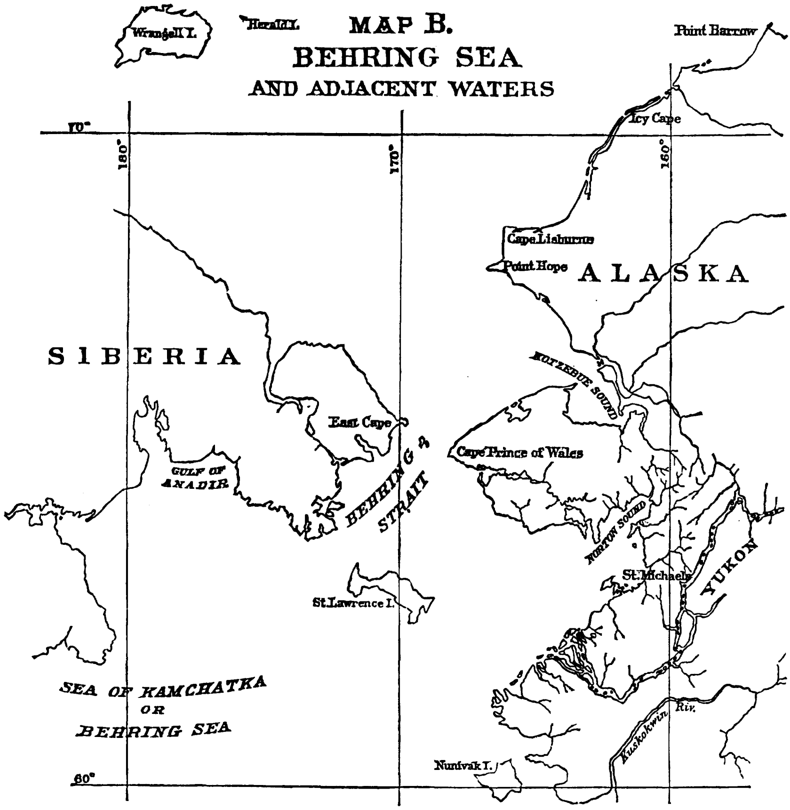
* On Map A may be found the lines of Captain Belknap's soundings.



Behring sea and waters contiguous may be considered at separated from the North Pacific by latitude 60° N. as its southern boundary, with latitude 70° N. for its northern limit, thus embracing in the strait and contiguous waters 10 degrees of latitude, and having the Arctic circle divide it into almost equal halves; having, where narrowest, a breadth of 49¼ nautical miles, with a depth not exceeding 27¾ fathoms. (See Maps B and C.)* Asiatic shore ice was seen at the times of observation by United States Coast and Geodetic Survey in August and September, 1880: Two small islands, the Diomedes, lie midway in the strait, dividing it into two channels. A warm oscillating current passing back and forth along the American shore toward Point Beechy, with a temperature of 48° Fahr. in summer, and a velocity of one foot per hour. This occurs only during warm weather. The Asiatic side was fringed with shore ice for a few miles out, and with its water temperature alongside at 37° Fahr., increasing to 45°–46° at the big Diomede isle without distinct current being observed. Arctic icebergs have not been observed within the straits; indeed it is too shallow to permit large masses of ice to pass through: one standing higher than twenty feet above water would have difficulty in brushing over the crest of the channel at side shallowest part, so that the straits are only a passage for broken shore ice and pack ice in spring and summer. Slow currents of moving water were observed passing in the warmest season of the year both northward and southward on opposite sides of the strait; but as Mr. Dall declares that there is an unobstructed flow of water through the channel for only ninety days in the year, it must be obvious that but a small amount of water from the Pacific can flow northward into the icy ocean. Indeed Mr. Dall, making a calculation, estimates the amount of water capable of passing north by this channel for one year would not fill a space having half the dimensions of Kotzebue sound. This incapability of these straits serving as an ample connecting link between the waters of the Arctic and Pacific, renders it only necessary to the arguments and facts of Professor Dall on this subject * to quote the passage from his report "No warm current from Behring sea enters Behring strait, with the exception of water from the neighboring rivers or adjacent sounds." This opinion coming from so eminent an authority as Professor Dall is final as regards these straits not forming a link between the two oceans; and if the connection of the ocean at the straits be null, the connection with the Kurosiwo south of the Aleutian isles is imperfect, the currents there being more probably purely tidal and capable of but little influence over either the temperature or the waters of Behring sea, the effect of whose efflux waters through the intervals of the islands is to cool the Kurosiwo.

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* For all accurate information of this intercontinental region I am mainly indebted to these publications from the pen of Professor W. H. Dall, who is the principal authority on all observations made on these coasts. Maps B and C are copied from the U. S. Geodetic Survey for 1880, Appendix No. 16.

As it might be interesting to know the physical appearance at such high latitudes as this in midsummer, a condensed extract from Appendix No. 16 is here added:

On Sept. 5th, Prof. Dall's party was off East cape. Broken ice lay close to shore.

With regard to the possibility of and the character of the herbage which this portion of the earth can sustain, Professor Dall relates that an exploring party on 20th August, 1880, anchored off Cape Lisbourne, on American shore, nearly 200 miles north of Behring strait; found the

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* Coast Survey Report for 1880, Appendix, No. 16.

air balmy, the sun warm and bright; no snow or ice visible on land and water, and the banks covered with flowers, among which daisies, monkshood, and forget-me-nots were conspicuous. Next day sailed for Icy cape and found ice approaching the land with the north wind; at that time eleven miles off land; that night the ice moved in three miles toward land; moved on next day to the latitude of Point Barrow, to a point 50 miles west of it, where vegetation, also quite dense, existed there, but less profuse than at Cape Lisbourne, and with fewer flowers.

At a depth of two feet below the surface of the soil a stratum of ice was met with (not frozen soil) of unknown depth, covered with a bed of clay and vegetation. This ice stratum extends with few breaks as far north as Point Barrow; it extends also to the east, rising to six feet above sea level. It then runs south certainly as far as Icy cape, and in different localities down to Kotzebue sound. This ice layer was again met with near Elephant point on the south shore of Escholtz bay—about half a mile from the sea a ridge two miles wide and 250 feet high was chiefly composed of solid ice overlaid with clay and vegetable mould, the clay in some places being six or eight feet thick. Dwarf birch alder, 7 or 8 feet high, with stems 3 inches in diameter, and a luxuriant growth of herbage and berries grew with their roots less than a foot from perpetual solid ice; generally the ground was in other places covered with moss, this ground being several hundred feet above the sea, higher than any land round about it and older in geological position than the mammoth, and buffalo, and the fossil horse which once tenanted these lonely slopes.*

The section of the water in the straits shows that it is warmest on the American side, and cools gradually as the Asiatic side is reached. The highest temperature shown was 48° Fahr. and36°. The the lowest vertical curves are here partly interfered with owing to the proximity of the Diomede isles, but are generally very regular. (See Map C. vertical isotherms.)

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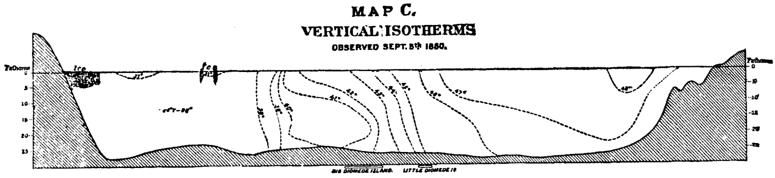
* Appendix No. 16, U. S. C. & G. Survey, 1880.



MAP C.
VERTICAL ISOTHERMS
OBSERVED SEPT. 5th 1880.

This examination of the temperature of the strait should clearly satisfy every observer that no cold current flows down in a body from the Arctic ocean, and that this shallow strait is an effectual barrier alike against it and any considerable current of warm water passing northward through the strait—any flow of warm water northward can only come from currents produced from winds or tides, both of which are powerful in the lower straits.

The Kurosiwo, east of 160° W. long., pursues its course south of the Aleutian islands along the parallels of 45°–47′ N. lat. with a southeasterly deflection, when it merges into and becomes an inseparable part of the drift current of the northwest coast of America. Important observations of this current have been made between Vancouver's island and San Francisco. In this long and curved course, the current has become altered in its thermic conditions, as stated previously ; it is no longer the warm current of this ocean, as it was when it travelled along the Asiatic shores in warm latitudes ; it has become, by commingling with the Behring sea waters and with the Alaska current, the cool current of the west shores of the continent, which it serves to chill so decidedly along the coast of Oregon and Washington

Territories, conferring a marked uniformity of climate as far south as San Diego, where the current has left the American shore and passed westward to mingle with the great body of the equatorial drift, to recommence its ceaseless round as the Kurosiwo.

An effort has thus been made to trace not merely a current but a circulation of warm water from the equator through the China sea, around the isles of Japan as far north as the Kuriles and the southern cape of Kamchatka, thence eastward and south of latitude 50°, toward the Aleutian isles, and from the promontory of Alaska to the shores of Sitka and Vancouver, nor is the idea of a circulating current a novelty ; it is an existing belief along the sea coast of China and Japan, and a tradition of the Spanish settlers of Mexico and California for three centuries.

The Japanese sea-going men are not only acquainted with the Kurosiwo, but know that in north latitudes it reaches American shores ; and I have learned, when in Kagoshima, the capital of Satsuma Ken, that it is no uncommon occurrence for Japanese and Corean vessels trading with Liu-Kiu to be compelled from stress of weather to put into that harbor, having been carried by the current several hundred miles to the north. Fishing boats and coast-traders going north to Nambu (Japan) from Osaka have been caught in the current during a storm and wrecked on the shores of Hokaido or the Kuriles. Greenhow* relates of the wreck of a Japanese vessel on the coast of Kamchatka in 1729 ; the same writer also states as a fact that two Japanese vessels under stress of weather have been driven on the west coast of North America since 1813.†

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* History of Oregon and California. Boston, 1844, p. 128.

† Ibid, p. 6.

The late Lieut. Day, U. S. N., engaged in Japanese survey of Hokaido in 1873, had learned of a Japanese junk drifting from Liu-Kiu to Nimuro (Hokaido) where the sailors were taken off and cared for by the authorities—originally bound to Kagoshima, but overtaken by a typhoon, they were so completely wrecked that they drifted with the current, and were carried to the very eastern point of Hokaido, having spent six weeks of an autumn struggling with the current.

HISTORICAL KNOWLEDGE OF PACIFIC CURRENTS.

No sooner had the Spanish adventurers from Cuba under Cortez landed in Mexico and conquered the then powerful and wealthy empire, than the reports of metallic and mineral wealth which were sent back to Spain, brought out crowds of adventurers eager for riches and renown, and the desire to discover and open up new and short routes to the Indies and Moluccas filled the excited minds of many, and of none more than of Cortez himself, who had received a charter from his sovereign empowering him to conquer and discover any islands or other countries west of Mexico and not then subject to other powers. He attempted to build ships and fit out an expedition from the Pacific shores, but meeting with opposition from Nuño de Guzman, the then governor of the territory in vicinity of the present Tampico, he was delayed for nearly three years before three ships were ready for sea; finally, in the summer of 1532, Cortez sent two of these vessels out, with instructions to sail along the Mexican coast in a westerly direction. At that time the most northerly points along the coast known to these adventurers was Culiacan. Diego Hurtada de Mendoza, the leader of the expedition, sailed from Tehuantepec along shore as far as latitude 27° N., where, owing to hardship and contrary winds, the crew mutinied and he sent the vessel back ; the other vessel he himself assumed charge of and started out for new exploration. What became of the ship or of Hurtado was never known, and Cortez fitted out two more vessels for further voyages; in one of these another mutiny occurred, the officers were killed and the ship put in on the coast at Chamotla, in the present Xalisco, where she was seized by De Guzman. The other vessel, under Grijalva, went to sea, discovered the Revillagigedo isles and then, tossed about by the winds, returned without having discovered any new shores. Again, in 1535, Cortez fitted out a third expedition, sailed up the coast and took possession of the southern portion of the peninsula of California, as now known. This settlement was in latitude 24° N., where he remained for one year, when the settlers mutinied, many of the crew having died from want and scurvy and the few who survived cursed Cortez, his islands, his bay and his discovery.*

From their ignorance of the existence and direction of the powerful currents of the ocean they could not avail themselves of the fortunate winds which blew in their favor, and hence singularly unfortunate were all the voyages undertaken to explore the northwest coast of this continent, whether by Cortez, De Guzman, Mendoza, Ulloa, Grijalva or Saavedra; tossed about by variable ocean winds, driven in to shore when they kept too close to land, driven out to sea if they ventured out too far from the coast, they found the ocean anything but pacific. After being beaten back southward to the port they had left, they abandoned exploration by sea and marched inland, northward into the heart of New Mexico, suspecting that the Indies might be there.

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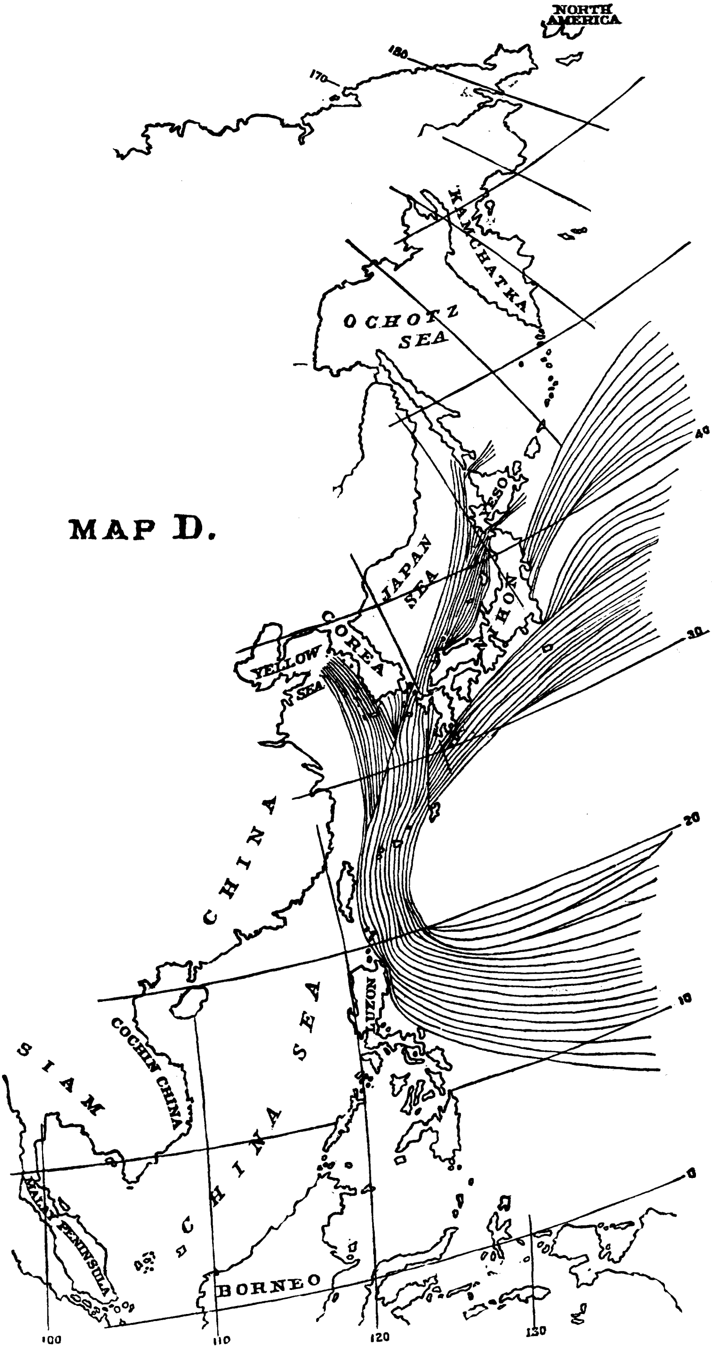
* Bernal Diaz. Istoria de la Conquista de Mexico, ch. 129.

MAP D.


NORTH AMERICA
180
170
KAMCHATKA
OCHOTZ SEA
YESO
JAPAN SEA
NIPHON
COREA
YELLOW SEA
CHINA
LUZON
CHINA SEA
COCHIN CHINA
SIAM
MALAY PENINSULA
BORNEO
40
30
20
10
0
100
110
120
130

By the term "the Indies," the Spaniards of that day did not understand either Hindustan or Cochin China. To them the Spanish dominions in America, together with the Canary and the Philippine isles, formed one empire called the Indies, of which the King of Spain was *ex officio* the sovereign, and it was to gain that Indies that so many ventures were made to reach them by a shorter route and in which they were successful, for in 1564 the mother country (Spain) made another attempt to gain a footing in the so-called East Indies. Miguel de Legaspé was sent out from Mexico in that year with a small squadron for that purpose. He landed on the Philippine isles and subjugated them, and if he failed to discover India, he made another discovery of great value to the world.

Before Legaspé's day no one had ever crossed the Pacific from Asia to America; in this voyage, however, three of Legaspé's vessels, with Friar Urdañeta as captain, on leaving Luzon sailed homeward in a *northerly direction* up to latitude 40°, aided by the variable winds of these latitudes, where he finally fell in with the eastern border of the Japan current on its eastern course to Californian shores, and there by the strong northwestern current was quickly carried to Mexico.

This was their discovery, that by sailing southeast from Mexico they would reach the great equatorial drift current running westward and known to Magellan, which would carry them from Mexico to China—to the Philippines—or to Macao—and by taking a northward course homeward they would invariably strike the northern current and be safely carried to the Californian and Mexican coasts.* This discovery enriched Spain and Mexico. Large ships, called galleons, sailed annually from Acapulco to Manila, to Macao, and the coast of Hong Kong, laden with precious metals and European merchandise, and bringing silk, spices, and porcelain for consumption either in Spain or America, and thus an extensive coast trade sprung up between the mother country and Panama, Peru, and Chili. These voyages were very long and very tedious ; usually from Mexico to India took three months to accomplish, and seven months in the return voyage, with the chances of the crew being decimated by scurvy.

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* This course may be better understood by reference to Map A, which indicates the direction of the equatorial drift, and also to Map D, showing its conversion into the Kurosiwo.

Yet long and tedious as they were, and fatal as the scurvy occasionally was, yet the glory and wealth which redounded to Spain, was deemed ample return, accomplished as it was with but trifling shipwreck or stress of weather, the sailing being in the track of the two great currents of the ocean, viz: the equatorial drift and the Kurosiwo.

Having resided for some years in Japan, and having been much interested in the meteorology and climate of that country, on my return voyage therefrom I was afforded an opportunity of studying the temperatures of the great ocean, by being permitted access—through the kindness of Captain Wm. B. Cobb, and Mr. Drinkwater, 1st officer of the Pacific Mail steamship *Great Republic* (to whom I here desire to return my thanks)—to transcribe from the log-books of the steamer, the records of the temperatures of the ocean during the trading voyages between San Francisco, Yokohama and Hong Kong, and the return trips.

As the ships of the P. M. S.S. Co. cross the Pacific every month, a favorable opportunity was thus afforded, not only of collecting information on the monthly variations of temperature throughout the year along the track of the voyages made, but also of determining the variations of temperature along the lines of longitude, so as to ascertain what influence the various currents in the ocean had in altering or modifying the heating and cooling effects of the solar rays upon that large body of water.

As these voyages were made along a prescribed route, from which deviation is made only exceptionally, and which route embraced a band of water about 16° of latitude in mid-ocean, very accurate information could be obtained of the monthly temperatures for successive years of the same region of the ocean; from which the existence of currents in the ocean may be assumed with considerable show of accuracy. For although sailing across a given latitude does not yield much knowledge of the velocity or direction of a current, yet where the temperature shows marked vicissitudes it generally implies the existence of a different body of water intruded along the sailing line, which is a current, and as it was only superficial temperatures which are recorded in the logs, it answered that purpose satisfactorily.

No doubt the only direct information yielded is the knowledge of the actual superficial temperature of the ocean; but over so large a body of water as the Pacific there must be differences of temperature over and above the differences of latitude and season, and these differences imply different movements and different forces acting, produced by strong winds, melting ice and solar heat. These three influences are shown very markedly upon a study of the table of temperature of the Pacific ocean taken on board the Pacific Mail Steamship Company's steamers in their trading voyages across the ocean between San Francisco and Yokohama, and their return trips, hereto annexed.

TABLE OF TEMPERATURES OF THE NORTH PACIFIC OCEAN.

Occurring on route of Voyages of Pacific Mail S. S. Co. Ship *Great Republic.*

Yokohama.		East Longitude.														West Longitude from Greenwich.																			San Francisco.		Voyage No.
Date.		140	143	146	149	152	155	158	161	164	167	170	173	176	179	178	175	172	169	166	163	160	157	154	151	148	145	142	139	136	133	130	127	124		Date.	
Feb. 6, '72..	Ar.	62	62	64	66	67	67	68	63	65	67	68	66	....	65	64	63	65	65	62	63	62	63	64	63	63	62	60	60	58	57	56	54	52	Sd.	Jan. 5, '72..	1
Feb. 1, '75..	Ar.	62	66	64	64	65	66	66	66	67	68	67	67	....	66	66	66	64	64	65	65	64	66	67	68	68	68	66	64	63	62	61	55	52	Sd.	Jan. 2, '75..	2
Feb. 24, '74.	Sd.	63	65	63	63	62	62	62	61	62	61	67	68	....	64	64	59	59	59	60	58	57	57	58	56	57	58	58	58	57	56	55	53	53	Ar.	Mch. 18, '74.	3
Mar. 11, '75.	Sd.	61	64	62	62	62	63	63	63	62	61	60	62	....	62	63	61	61	62	63	61	61	62	63	63	62	62	62	61	60	59	58	54	52	Ar.	April 3, '75.	4
April 27, '74.	Ar.	66	64	63	64	62	62	62	64	61	61	61	61	....	56	57	58	57	58	59	60	50	58	57	59	60	60	60	60	59	58	55	55	54	Sd.	April 1, '74.	5
May 28, '75.	Ar.	70	68	67	65	64	64	63	62	61	61	60	59	....	60	60	60	60	59	59	58	57	58	57	59	59	60	61	60	60	62	57	56	53	Sd.	May 1, '75..	6
May 25, '72..	Sd.	68	68	67	66	64	64	65	61	65	63	62	62	....	63	59	59	59	60	59	59	60	62	64	66	65	65	64	61	61	60	58	58	55	Ar.	June 17, '72.	7
†May 23, '74.	Sd.	62	63	64	67	67	61	60	60	60	59	58	59	....	59	58	57	57	56	56	55	55	53	54	56	54	54	54	58	59	60	60	59	53	Ar.	June 15, '74.	8*
June 24, '75.	Sd.	72	74	73	72	71	69	69	68	70	72	70	72	....	74	73	72	70	70	68	68	67	67	68	69	69	69	67	65	64	62	61	60	55	Ar.	July 16, '75.	9
July 20, '74.	Ar.	73	77	76	75	76	76	74	72	70	71	72	72	....	71	71	70	69	68	67	67	68	67	67	66	64	64	63	63	63	62	61	61	57	Sd.	June 27, '74.	10
July 24, '72.	Ar.	81	77	78	77	75	76	75	74	75	75	73	72	....	73	71	72	72	67	67	66	67	67	67	66	66	67	66	65	65	63	62	56	55	Sd.	July 1, '72.	11
†Aug. 26, '75.	Ar.	80	82	78	81	80	79	80	79	78	78	77	76	....	77	76	75	75	75	73	72	71	71	72	72	70	71	71	66	65	64	63	61	55	Sd.	Aug. 2, '75.	12
*Aug. 14, '74.	Sd.	80	82	78	77	75	64	58	58	57	56	55	53	....	55	55	55	55	55	57	60	60	61	61	62	63	63	62	64	64	64	65	63	62	Ar.	Sept. 8, '74.	13†
†Aug. 22, '72.	Sd.	80	82	79	78	76	76	75	75	76	77	76	76	....	73	73	75	75	74	74	74	75	75	75	74	74	73	72	72	70	69	68	67	66	Ar.	Sept. 12, '72.	14
Oct. 9, '73...	Ar.	....	75	74	73	74	75	78	80	82	76	73	70	....	69	69	69	69	70	69	70	70	71	73	74	74	74	74	73	71	69	68	64	62	Sd.	Sept. 16, '73.	15
Oct. 25, '71..	Ar.	....	76	76	76	76	78	77	79	79	79	79	78	....	77	78	78	77	77	77	78	79	79	78	76	77	75	73	70	67	66	66	65	62	Sd.	Oct. 1, '71..	16
Nov. 2, '73..	Sd.	68	72	72	71	71	72	73	78	72	69	72	71	....	67	66	66	66	66	65	62	62	62	62	62	64	64	68	67	66	66	66	58	56	Ar.	Nov. 23, '73.	17
Nov. 23, '74.	Sd.	72	73	70	72	72	72	75	73	72	72	72	72	....	69	69	69	69	69	69	69	69	68	68	67	67	66	66	65	64	63	62	60	56	Ar.	Dec. 18, '74	18
Nov. 23, '71.	Sd.	66	68	71	72	74	70	73	72	71	71	70	69	....	67	66	66	65	65	65	67	66	66	67	67	68	68	66	65	64	60	58	55	52	Ar.	Dec. 15, '71.	19
Dec. 23, '73.	Ar.	63	66	67	70	69	68	70	71	70	70	69	70	....	69	60	69	69	69	69	69	70	71	69	69	70	70	71	65	65	66	65	64	60	Sd.	Dec. 1, '73.	20

Through the kindness thus extended toward me, I was enabled to obtain complete returns of the temperatures of twenty-four voyages made by that ship, which are tabulated so as to show the temperature on every third meridian on the sailing line. Twenty of these voyages are recorded in the table. The Asiatic shore (Yokohama) being placed on the left side of the sheet and San Francisco on the right; on each side are recorded the dates of sailing (Sd.) and arrival (Ar.) of each voyage. The sailing line is nearly on an even parallel, the latitude of Yokohama being 35° 27′ N. and San Francisco being 37° 30′ N. To obtain those figures daily averages of the temperatures recorded in the log-book were struck, and these daily means were transferred to the table. The majority of these trips were made on the southern route, which reached in its most southern part latitude 30°; the few on the northern route *are marked with an asterisk* and reached occasionally to 46° N. latitude.

The table of temperatures of the North Pacific ocean here submitted is drawn, as stated, directly from the logs and arranged for comparison on every 3d meridian. The fractions of a degree are either omitted when slight, or raised to the next degree to avoid complexity in calculation while not materially altering the correctness of the results.

I have also added five profiles of the temperatures in degrees of Fahrenheit along the sailing lines across the ocean for every month, in which the curves of temperatures are graphically shown and the difference of the temperature of the seasons can be distinctly appreciated.

The seasons along the coasts of the North Pacific are not to be reckoned as four in number each of three months duration; they are governed wholly by the monsoons and are really divisible into two, as winter and summer, the length of which vary in proportion to the latitude.

The arrival and departure of seasons over the Pacific ocean is very different from that in the case of the Atlantic. Having no outlet for its waters in the north, the Pacific is not warmed by the rapid flow of a large body of warm water flowing into the Arctic seas, but by the travel of a wider and shallower stream meandering in a circular path and adding the warmth of intertropical waters to modify the cold of Arctic latitudes. Thus the warmth of the Pacific in latitudes above 50° is derived from the connected currents crossing from west to east,* and from shallow sea bottoms of the Aleutian seas and archipelago of the Northwestern Pacific, warmed by solar radiation. The vast central area of the great ocean is warmed by solar radiation alone; its surface kept in constant movement equalizing its temperatures; and prevented as it is from being cooled down by the fact that no great icebergs come down through Behring straits or sea; and finally because the Kurosiwo in early summer moderates the cold of the Oya Siwo formed by the melting of the ice waters of the sea of Ochotz, the warmth of September and October lingers into the following spring.

In order to understand the cause and variation of the temperatures of the Pacific ocean it will be necessary to compare the table of the twenty voyages of the ship *Great Republic*, in which the temperatures of every third meridian are set down, with the diagrams of the same voyages arranged by months, and to consider these latter by the amount of deviation from the condition of most perfect equilibrium of the ocean. If attention be directed to voyages Nos. 3 and 4 (see profiles) it will be seen that the uniformity of temperature is greater along these two lines than on others. Along the line of voyage No. 5 the temperatures from meridian 179 W. Long (Gr.) to American shore are also lower, but the temperatures on the Asiatic half are somewhat increased.

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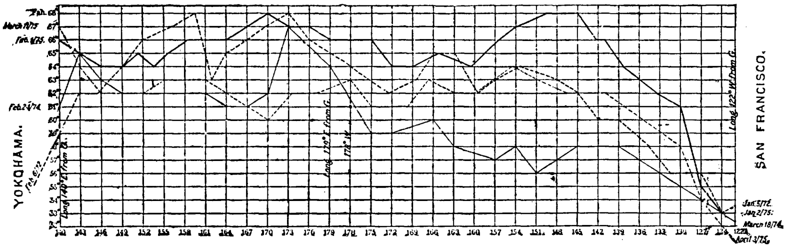
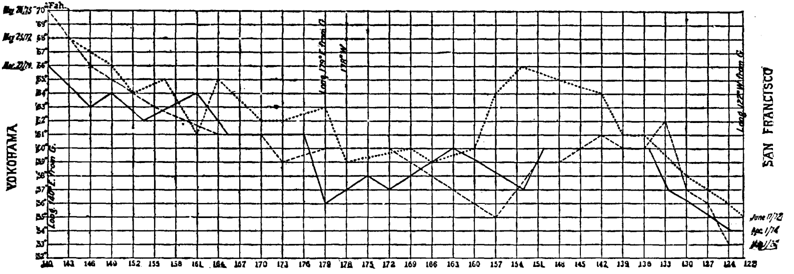
* *i. e.*, from Asia to America.

PROFILE OF VOYAGES No. 1.



In fact the northern movement of the current is shadowed forth in the slightly augmented temperatures along meridians 140° to 149°. Voyages No. 4, therefore, may be accepted as representing those temperatures of the ocean when it is unmoved by any warming or cooling influences; the mean temperature of the voyage is 60°.1 Fahr., which may be looked upon as the mean temperature of the latitude of the sailing line. As the temperatures of the first twenty degrees is slightly above this figure, it would appear that the ocean had not time or opportunity to cool down to the normal figure throughout the winter before the warm current of the next spring makes its appearance at the

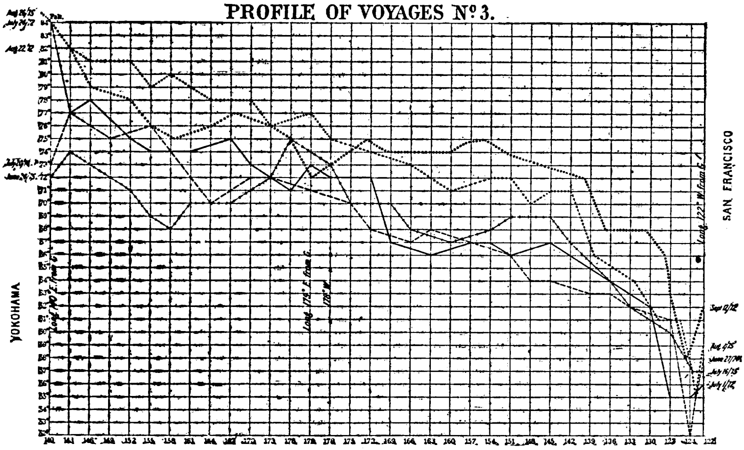
PROFILE OF VOYAGES No. 2.



locality. April is the month when the current makes itself evident in latitude 35° on the Asiatic side.

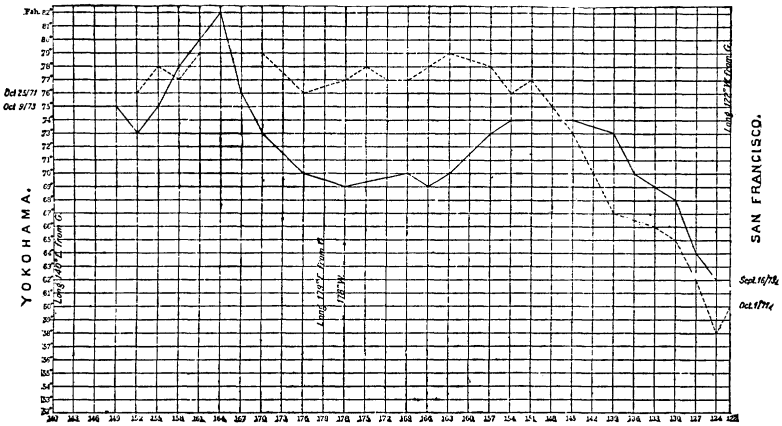
Voyage No. 5, which started from Yokohama, April 1, 1875, experienced no warm waters until approaching Japanese shores, when, under meridian 149°, the temperature of 64° was encountered, with slightly elevated temperatures, until port was reached ; thus the first approach of the current is along shore, and each month, as a greater body of warm water advances north with greater warmth, this warmth is shown by its extension seaward; thus, in May and June the increased volume and temperature of the Kurosiwo is shown by the warmth extended farther out to sea, as far as 160° east in May. June is not a summer month on this sailing line, but even in June the Kurosiwo is felt as far east as 175°, although I doubt if a current flows east of 175° east longitude. By reference to the general map on page 101, this will be seen to be the meridian of Behring strait, and on the "Table of Temperatures," as well as on the diagrams of voyages, this meridian will be found a dividing line, all high temperatures being on the Asiatic side of that meridian.

PROFILE OF VOYAGES No 3.



Summer in Japan is represented by the months July, August, September, and sometimes half of October; summer is late and protracted. The season is similar along the Chinese coast, and is exemplified on the "Table" by Voyages 11, 12, 13, 14 and 15, and by profiles Nos. 3 and 4. Voyage No. 14 illustrates the most heated condition of the Pacific waters; but even in the summer months, temperatures above 70 are not found east of meridian 136°. The melting ice waters of Behring's sea, Kamchatka, and above 55° north latitude, make themselves apparent in the "Table" and profiles by the lower temperatures in mid-ocean and toward America, where this cooling agent flows across the Kurosiwo, then running toward Vancouver's island, and reducing summer temperatures down to 60° Fahr.

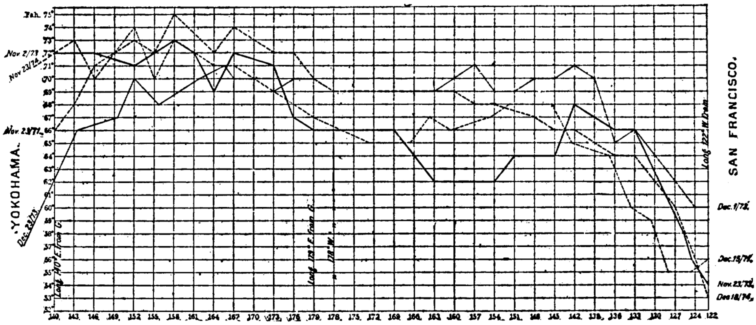
PROFILE OF VOYAGES No. 4.



Voyages 8 and 13 were made along the northern route, sailing part of the time along parallel 46, and shows the differences of temperatures between latitudes 31 and 46.

The waning power of the Kurosiwo is indicated in Voyages Nos. 16, 17 and 18 (see profile No. 5), where temperatures of 70 are not found on leaving the California coast after October 1st, until Meridian 177° is reached. In the months

PROFILE OF VOYAGES No. 5.



of November and December the warm current has disappeared between latitudes 30° and° 40, the whole ocean is cooling down, and the influence of the Asiatic shores as refrigerators is apparent; the N. E. monsoon has set in and continues during the first three months of the new year to bring down the condition of the surface of the Pacific to that condition of equilibrium in which no warmth is communicated from the air to the ocean. The S. W. monsoon has ceased to blow and the Kurosiwo as a current disappears, although its warming and equalizing diffusion continues in a mild way.

Such is the sketch of the currents of this great ocean which I have endeavored to place before you—slight and imperfect it necessarily is, needing further and more minute observation to be fully comprehended. But I have endeavored to clearly describe the two peculiarities of the Pacfic ocean, namely:

First.—That the warming influence of the North Pacific is the Kurosiwo or the Japanese current, which encircles this vast expanse of water; the motor power of which is the southwest monsoon, blowing from April until October.

Second.—The North Pacific ocean has, practically speaking, no northern outlet; Behring strait is but a *cul de sac*, and is no real gate of entrance into the Arctic ocean.